UNITED STATES PATENT APPLICATION

MODULAR TRUSS SYSTEM
WITH A NESTING STORAGE CONFIGURATION

INVENTOR

Steve Lewison
14269 Aspen Ave
Prior Lake, MN 55372

MODULAR TRUSS SYSTEM WITH A NESTING STORAGE CONFIGURATION

Cross Reference To Related Applications

This application claims the benefit of U.S. Provisional Application Serial Number 60/441,401, filed January 21, 2003, under 35 U.S.C. §119(e) which is incorporated herein by reference in its entirety.

Technical Field

The present subject matter relates to truss systems, and in particular to modular truss systems for transportable structures.

Background

It is known to provide a truss with a framework comprising interconnected chords where the truss is elongate with a square or triangular transverse cross section. These truss arrangements take up a great deal of room once disassembled and are thus expensive to store and transport.

One known system provides a truss in which the chords are foldable to take up less room for storage or transport. However, these trusses are weaker and more expensive to manufacture.

Another known system nests truss modules, and involves not installing webbing on one face. On the remaining faces, structural V-shaped formers are substituted for the webbing to prevent splaying of the chords in the open face. However, these formers are heavier than typical webbing members which serve as simpler axial two-force members.

Another known system nests truss modules, and includes removable cross-bracing on an open face, where the cross-bracing is removed for storage. However, this method adds parts, complexity, assembly time and cost to the design.

Summary

Various embodiments of the present subject matter provide modular truss span components with fixed, rigid structure on all faces which allows for assembly into useful configurations. These components are also readily nest-able into compact stacks for storage and transportation without folding or removing elements.

One aspect generally relates to a truss span. One embodiment of the truss span includes at least three chords in a generally parallel orientation with respect to each other, where adjacent parallel chords provide a face of the truss span such that the at least three chords provide at least three faces. The truss span includes a web that connects two adjacent parallel chords that corresponds to at least two of the at least three faces to provide the truss span with at least two webbed faces. The truss span further includes a first structural end bracket and a second structural end bracket that connects two adjacent parallel chords corresponding to at least one of the at least three faces to provide the truss span with at least one open face. The first end bracket connecting a first end of the two adjacent parallel chords and the second end bracket connecting a second end of the two adjacent parallel chords provide an open face area between the first and second structural end brackets. The truss span has a tapered profile such that another identical truss span is capable of nesting within the open face area between the first and second structural end brackets.

One aspect generally relates to a system, comprising a plurality of truss spans. Each truss span includes at least three chords in a generally parallel orientation with respect to each other, where adjacent parallel cords form a face such that the at least three chords form at least three faces. Each truss span also includes a web connecting two adjacent parallel chords for at least two of the at least three faces. At least one of the three faces has two adjacent parallel chords connected by two structural end brackets. The plurality of truss spans has a tapered profile and a stacked configuration where a first truss span nests inside of a second truss span when the first truss span is inserted between the two structural end brackets of the second truss span.

One aspect relates to a joint system for joining truss spans having truss chords where at least a portion of the truss chords are hollow. According to an embodiment, the joint system includes a first access opening in a first hollow portion of the truss cord proximate to a first end of a first truss chord and a second access opening in a second hollow portion of the truss chord proximate to a second end of a second truss chord. The joint system further includes a first end plug with an aperture at the first end of the first truss chord and a second end plug with an aperture at the second end of the second truss chord. The joint system further includes a fastener extending through the aperture of the first end plug and into the aperture of the second end plug.

This Summary is an overview of some of the teachings of the present application and not intended to be an exclusive or exhaustive treatment of the present subject matter. Further details about the present subject matter are found in the detailed description and appended claims. Other aspects will be apparent to persons skilled in the art upon reading and understanding the following detailed description and viewing the drawings that form a part thereof, each of which are not to be taken in a limiting sense. The scope of the present invention is defined by the appended claims and their equivalents.

Brief Description of the Drawings

FIG. 1 is an isometric view of an embodiment of a triangular nesting truss span with integral structure on all faces.

FIG. 2 shows a truss span of FIG. 1 nested for storage or transport with a stack of identical truss spans.

FIG. 3A show an assembled view of an embodiment of a hub system.

FIG. 3B show an exploded view of an embodiment of a hub system.

FIG. 4 shows some assembly configuration options for the hub system of FIG. 3A.

FIG. 5A shows an embodiment of a joint system.

FIG. 5B shows an assembled view of the joint system of FIG. 5A.

FIG. 5C shows an exploded view of the joint system of FIG. 5A.

FIG. 6 shows a stack of branches, illustrated in FIGS. 3A and 3B, nested for storage or transport.

FIGS. 7A-7D show an isometric view of a pair of truss, previously illustrated in FIG. 1, and a process for nesting one truss within the other truss.

FIGS. 8A and 8B show end bracket embodiments with thinner mid-sections and corresponding functional webbing clearances.

FIG. 9 is an end view of a truss and illustrates how web connections are offset to create additional clearance when nested in stacks.

FIG. 10 illustrates an example of an assembled truss system which includes curved and straight truss elements according to various aspects of the present subject matter.

Detailed Description

The following detailed description of the present subject matter refers to the accompanying drawings which show, by way of illustration, specific aspects and embodiments in which the present subject matter may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the present subject matter. Other embodiments may be utilized and structural and logical changes may be made without departing from the scope of the present subject matter. References to "an", "one", or "various" embodiments in this disclosure are not necessarily to the same embodiment, and such references contemplate more than one embodiment. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope is defined only by the appended claims, along with the full scope of legal equivalents to which such claims are entitled.

FIG. 1 is an isometric view of an embodiment of a triangular nesting truss span with integral structure on all faces. The truss span 101 is an assembly consisting of tubular chords 119, 120 and 121 joined in a parallel fashion with end brackets 123 on one face and webbing 122 on the others. The end brackets 123 have a profile with a narrowed mid-section (see 899 in Fig. 8A) to create clearances

for stacking similar truss spans 101 (see Fig. 2) and widened profiles (see 898 in Fig. 8A) at the points in which they are connected or welded to the chords for maximized structure. Various embodiments of end bracket have hole patterns 125 which provide for a simplified means of attaching other components and attachments, and can accommodate u-bolts sized to secure components of the same outside diameter as the chords 119, 120 and 121 as needed. In the illustrated embodiment, the web 122 is angled and triangulated to provide additional structural strength and leaves open regions (illustrated at 897 in FIG. 8A) with web offsets 126 from the ends of the chords. These web offsets 126 are opposite the end brackets. In various embodiments these web offsets 126 measure at least twice the width of the narrowed mid-sections (illustrate at 899 in FIG. 8A) of the end brackets 123 to allow for nesting of similar truss spans 101 in stacks of unlimited quantities. This embodiment shows end plug 124 joint features which have a through hole and are secured or welded to the ends of the tubular chords 119, 120 and 121 and provide for bolts or other joint methods to secure similar truss spans 101 or other compatible components in a serial manner. The ends of tubular chords 119,120 and 121 have access holes 127 cut through the side walls of the tubes near the end plugs 124 to allow for the installation and securing of bolts and other fastening systems. (See FIG. 5A-5C)

FIG. 2 shows the truss span of FIG. 1 nested for storage or transport with a stack of identical truss spans. This truss stack 250 can be created with the end brackets up (as shown), with the end brackets down (on the floor) or with the open features of the truss facing in another direction. The stack (as shown) is started by orienting one truss span with the end brackets up and by introducing a like truss span 201 in a similar orientation (see FIG. 7A). One end of the additional truss span 201 is then shifted slightly off-center (see FIG. 7B) to allow one bottom chord to drop just inside the other end bracket of the previously stacked truss spans. In the angled fashion shown in Figure 2, the bottom chord can then be shifted off-center in the other direction (see FIG. 7C) under the end bracket(s) of the previously stacked truss spans. The end that is not yet nested can then be lowered into place and this added truss span 201 can be re-centered to form a uniform stack (see Fig. 7D). This

process can be continued as needed for compact storage. The first truss span does not result in any space savings but every additional added truss sections nests within the stack and adds only a little more height than the chord diameter of the truss system. FIG. 2 show a truss span being added to a stack of sixteen truss spans and illustrates how this truss system can stack infinitely when a small amount of space is maintained, often with spacers, to allow the end brackets 123 (Fig. 1) to sit between the ends of the bottom chord 121 (FIG.. 1).

In an embodiment with three parallel 1 inch OD tubular chords on 10 inch centers and 48 inches long, nesting the first two truss spans together results in a 35% cross-sectional space savings and the space savings percentage increases as units are added. Eight units or more results in a 65% cross-sectional space savings or better. A space savings exceeding 70% can be achieve in large stacks of 20 or more units and provides for very efficient commercial storage and shipping. The resulting stacks of truss spans, once aligned, create long internal voids between the webs which provide additional space to store other system components, hardware, graphics, or accessories.

FIGS. 3A and 3B show an assembled and an exploded view, respectively, of an embodiment of a hub system. FIG. 3A shows an embodiment of an assembled hub system and related truss members, hubs, branches and fasteners and FIG. 3B shows an exploded view of FIG. 3A and also illustrates that branches can be assembled in a flipped orientation with the single tube of the branch at either the top or the bottom.

FIG. 3A and 3B illustrate how truss spans 301 (also illustrated as 101 in FIG. 1) connect to modular branches 302 and connect to modular hubs 303. The branches 302 have joint systems that can connect with truss spans 301 and in this embodiment the branches 302 have similar end plugs (illustrated as 524 in FIG. 5B) The end plugs are joint features which have a through hole and are secured or welded to the ends of the tubular chords 119,120 and 121 and allow bolts or other joint methods to secure truss spans 101 or other compatible components in a serial manner. The tubular ends of the branches 302 have an access hole 327 cut through the side walls of the tubes near the end plugs to allow for the installation and

securing of bolts and other fastening systems such as illustrated in FIG. 5A-5C. The branches have cradles 367 which connect to modular hubs 303. In this embodiment, the branches are secured with hub bolts 304 and knobs 305. In this embodiment, these bolts fit through an arrangement of holes 369 and slots 370 which provide for branches 302 to be attached in multiple configurations. In this embodiment, the holes 369 are square to provide a self locking feature for the bolts 304 which have heads with enlarged mounting faces to distribute load stress and allow for thinner and lighter walls on the central cylinder of the hub 303. In this embodiment the large mount faces of the bolts 304 are efficiently produced from the slugs cut from the access holes 368 of the central tubular cylinders of the hubs 303. In this embodiment, these bolts 304 attach through rectangular tubes 328 of the branches 302 and can be secured with knobs 305 or nuts. These rectangular tubes 328 are capped at its ends with custom sheet metal cradles 367 which match the OD of the central cylinders of the hubs 303. The tabs 365 on these cradles 367 are angled, one up and one down, to allow them to clear each other when branches 302 are attached to the hubs 303 at close angles like 40 degrees as illustrated in FIG. 4. In this embodiment the branch cradles 367 also have tabs which fit the inside the tube elements of the branches and provide means to align and secure the tubes with processes like welding. The wire web 364 secured on the branches 302 provide structure and an aesthetic continuation of the webs on the truss spans 301 as shown in FIG. 3A.

In the illustrated embodiment, the hubs 303 have a central tubular cylinder with two patterns of holes 369 and slots 370 around its diameter which provide for a wide variety of assembly configurations. Additional larger holes are included to provide finger access for assembly and to reduce the weight of the hub. The three connection tabs 372 have through holes for connection to the ends of truss spans 301, which can commonly form vertical pillars (See FIG. 4). In this embodiment these tabs are connected to the central cylinder by means of tapered brackets 371.

FIG. 4 shows some assembly configuration options for the hub system of FIG 3. The truss spans 401 can serve as horizontal and vertical structure. In this embodiment, up to eight branches 402 can be attached to a hub 403. This figure

shows four branches 402 attached to a hub 403 and illustrates that the hole and slot patterns of the hub 403 allows for a variety of angles. The tapered nature of the branches 402 allow the truss spans to connect at narrow angles. In this embodiment the branches can mount at angles as narrow as 40 degrees. One of ordinary skill in the art will understand, upon reading and comprehending this disclosure, that the system can be designed to provide other angles or increments of angles. This figure also shows that branches 402 and truss spans 401 can be mounted with the single tube of the branch at either the top or the bottom as illustrated by the components on the right side of FIG. 4. With this angular and mounting versatility a wide variety of structural configuration can be achieved.

FIG. 5A shows an embodiment of a joint system. FIG. 5A shows a standard truss span, a half length truss span (24 inches long in this embodiment) and a branch component. Two of the joint locations are circled and reference FIG. 5B which shows the nature of the tubular joint system of this embodiment. This joint system is used to join the chords of standard length truss spans 501, fractional length truss spans 551, branches 502 or compatible components like the three connection brackets 371 of the hubs,

FIG. 5B shows an assembled view of the joint system of FIG. 5A. FIG. 5B shows the end plugs 524 secured, such as welded, in the ends of the tubular chords and the access holes 527 in the wall of the tube. Figure 5B also shows how a bolt 530 and nut 531 secures a chord section.

FIG. 5C shows an exploded view of the joint system of FIG. 5A. FIG. 5C shows how the access holes 527 in the tube wall allows for the installation and wrenching of bolts 530, nuts 531 or other securing hardware through the end plugs 524. An embodiment of the joint system has a bolt 530 wherein the drive head has a diameter smaller than a diameter of a flange of the bolt. An example of such a bolt is a bolt with a twelve-point-drive head. An embodiment of the nut is a serrated or other self-locking flange nuts 531. This off-the-shelf hardware simplifies and speeds up the assembly process. The twelve-point bolt 530, with the smaller drive size allows smaller, common wrenches to tighten the bolts in the limited space inside the chords and access holes 527. The serrated flange nut 531 secures itself

once it is finger tightened and does not require the use of a second wrench. When tightened, the clamping nature of the bolts removes gaps and pre-loads the joints to minimize slop between the truss system components, even when loaded. The smaller head on the twelve point drive bolts 530 results in simplified assembly since only common twelve-point wrenches are required. This arrangement also allows assembly speed to increases when ratchet style twelve-point box wrenches are used. This nesting truss system illustrated in FIG. 2 allows for various truss span features and joint designs.

FIG. 6 shows a stack of branches, illustrated in FIGS. 3A and 3B, nested for storage or transport. The open nature of the branches 602 allows for easy nesting into branch stacks 652. In this embodiment, a stack of two branches saves about 35% of the required storage volume. A stack of four branches 652, as shown, saves about 50% of the required storage volume. A stack of eight branches saves about 58% of the required storage volume.

FIGS. 7A-7D show an isometric view of a pair of truss, previously illustrated in FIG. 1, and a process for nesting one truss within the other truss. These figures sequentially illustrates how truss spans 701 are stacked in pairs or larger stacks (illustrated at 250 in FIG. 2) by first inserting one end of a truss span to be added to a stack (illustrated in FIG. 7B), then shifting the truss span past center (FIG. 7C) to created clearance for the second end, and then inserting and re-centering the added truss span (illustrated in FIG. 7D).

FIG. 8A and 8B shows various embodiments of end brackets (illustrated at 123 in FIG. 1) and webs (illustrated at 122 in FIG. 1) with profiles and clearance areas which allow truss spans to nest in a compact manner (illustrated in FIG. 7A-7D). As illustrated in both FIG. A and B, the narrow sections 899 of the end brackets create clearance for central chords 121 as truss spans are nested. The wide sections 898 of the end brackets allows for increased strength. The resulting triangulated outer sections of the end brackets effectively stiffens the member and provide additional connection area for securing the bracket to the chord with weld, adhesive and the like. The end brackets effectively prevent outward movement of the attached chords 119 and 120. The triangulated outer sections of the end brackets

additionally resist racking movements of the open face. This arrangement means that the chords 119 and 120 are less prone to move parallel to each other. The structure of the end brackets 123, combined with the webs, adds stiffness to truss spans under several different load conditions including torsion around the central axis of the truss span 101. FIG. 8A and 8B illustrates various embodiments of end brackets 123 which resist splaying and racking of the attached chords. FIG. 8A shows an end bracket embodiment made of profiled plate or sheet material and FIG. 8B shows an end bracket embodiment of an assembly of elongated members. FIG. 8A shows a web embodiment made of at least one elongated member such as a continuous wire or separate wire elements. FIG. 8B shows a web embodiment made of profiled plate or sheet material. Nesting truss spans 101 have web embodiments with open regions 897 which allow the web faces to clear the end brackets 123 as truss spans are nested as shown in FIG. 7A-7D. Truss spans 101 have web embodiments with open regions 897 which are sized to allow nesting clearance on truss span with various end bracket embodiments.

Various embodiments of the truss spans 101 include removable braces 892 attached across the open face formed between the two end brackets 123 and the chords 119 and 120 of a truss span 101 and can be detached or folded before creating nested stacks.

FIG. 9 shows that in some embodiments the connection points of the webs 922 to the chords are offset in a manner to minimize truss stack height and volume (illustrated as 250 in FIG. 2). In some embodiments, the webs 922 are secured in orientations that are angled relative to the planes created by the adjacent chords or the center-to-center lines 922 connecting the center of the chords. Stack size is minimized when the attachment points of the webs 922 to the center cord 121 are shifted outward increasing region 995 and the attachment points for the other chords 119 and 120 are shifted inward increasing region 996. This assembly of web members at irregular angles prevents interference of the webs 922 with the chords of adjacent truss spans as they form stacks (illustrated as 250 in FIG. 2).

FIG. 10 shows one embodiment of an assembly configuration of the truss system. The central hub 1003 is shows an arrangement without any vertical truss

attached to form columns. The other hubs 1003 illustrate arrangements with truss columns created with truss spans 1001. Branches 1002 are shown connected to truss spans 1001 and assembled to hubs at a variety of narrow and wide angles. The hubs 1003 are shown assembled with different numbers of branches. FIG. 10 shows a curved truss embodiment 1093 of truss spans 1001. The end brackets of the curved truss are fixed to the face on the outer radius and maintain the ability to create compact stacks like those created by straight embodiments of the truss spans (illustrated as 250 in FIG.2). FIG. 10 illustrates the versatility of this modular truss system

The truss can be used where compact storage, transportability, or easy-to-configure structures are needed in applications like, but not limited to, trade-show displays, commercial displays, concert and performance venues, dance floor lighting, outdoor tents, shelter systems and other support systems.

In one embodiment, the truss system has a triangular cross-section. Other nesting shapes are possible, and are within the scope of this disclosure. Truss spans with a tapered transverse cross-section like triangular and trapezoidal allow nesting. The truss system features one face in which the common truss webbings are replaced with end brackets which leave one face open and allows the components to nest together in a compact manner (like paper cups) for storage and shipping.

The end bracket supports achieve structure and an ability to nest with thin member in the middle section and a triangular shape connecting to the adjacent truss chords.

This one piece truss arrangement, along with other specific truss webbing features, allows compact storage and shipping, and also achieves a simplified, one piece assembly which is more economical to produce than other multi-piece, folding truss systems.

In one embodiment, the joint system in the truss assembly'(IE. built on 1 inch OD tubing) relies on common (in this application 3/8 inch) fasteners bolted through holes in end plugs welded to the truss tubing and accessed through access cut outs near the ends of the truss tubing.

This readily transportable truss having various embodiments with one face which is framed in with structural end brackets allows the truss to nest with other similar trusses in a storage configuration and provides for fixed structure on all faces with web members or end brackets.

Two of the three or more chords are rigidly connected by two end brackets; with a necked down area and specifically designed to form a structural face with unobstructed midsection which, with solid, hollow, or internally reinforced chords, can resist splaying and racking forces. Additional chords are rigidly connected parallel to the two chords, to form a triangular or other tapered transverse cross-section and are connected by web members (wires or other plate members) in a rigid manner and that can resist splaying or racking forces on the attached chords.

This truss arrangement, with structural end brackets on one face, provides open regions at the ends of other webbed faces to provide for the ability of the components to nest. The web members (wire or other plate type elements) connected to the third chord leave an unobstructed region at the end of the chords opposite the end bracket. Web members and the unobstructed regions have various embodiments. When web members have a gap from the end of the third chord of a distance of at least twice the thickness of the narrowed midsection of the end brackets of the truss and have angled profiles as to not interfere with the end brackets of trusses as the trusses are nested, stacks of unrestricted quantities can be made without interfering with the end bracket as the stacks are increased. In various embodiments, webs with sufficiently angled profiles but without a sufficient gap from the end of the third chord can be nested into stacks of limited quantities. Truss stack are made by first inserting one end, shifting it past center, dropping the other end in and re-centering the truss. This arrangement applies to truss embodiment in which the chords are straight or curved.

This truss arrangement, with additional similar truss, allow for a modular truss structure, where the trusses are joined end to end in serial alignment by means of various jointing system embodiments.

This truss design provides for a stacked truss arrangement comprising at least two trusses, being stacked on top of and inter-nested with one another.

A reconfigurable modular truss hub arrangement with a cylindrical hub or core can connect to truss elements in an axial (typically vertical) manner, on the top and bottom, with fixed or attachable connectors to form pillars. The hub arrangement incorporates means of attaching radial (horizontal) branch truss connectors which can be added as needed to form a variety of truss structure configurations and utilizes specifically designed pairs of both holes and slots which provide a versatile degree of security, alignment, and angular options.

The branch system complements the truss hubs system and provides one end for attachment to truss members and the other end designed for connection to cylindrical hub component with structure which tapers to a tall, narrow profile which allows for adjacent branch truss connectors to mount at various angles, even uniquely narrow angles like 40 degrees, to each other and allowing for beneficial versatility, while still resulting in sufficient resistance to many common forces and moments developed by applied torques and cantilever type loads due to its two points of fastening the branches to top and bottom locations on the hub and the inclusion of concave cradles on the upper and lower parts of the branches which match the cylindrical core of the hubs and produce a widened base which resists lateral forces and movement of the branches and attached truss components in the radial plane, and incorporates additional and beneficial width of this cradle by angling the ends of the cradles on one side of the branch at a slight angle up and the other down thereby allowing the cradles of adjacent branches mounted at small angles to not interfere with each other and all the while the tapered branches have open aspects which allow them to nest in compact branch stacks for storage and transport.

A joint system for securing the chords of the truss system components which incorporate tensile fasteners (threaded, quarter-turn, C-clamp style, or otherwise) inserted through windows produced in the side of the hollow chords and through holes in end plugs welded in the ends of the hollow chord such that the chords and attached assemblies are secured with a multitude of fastening embodiments which includes securing with commercially available 12 point drive bolts and tightened with common fixed or ratcheting box wrenches or securing with standard hex head

fasteners which are tightened with custom wrenches low profile wrenches which in turn fasten to various nut embodiment which includes "serrated flange nuts" which resist rotation as the mating bolts are tightened allowing this joint system to not require a second wrench. The simple through hole design is genderless and does not require any special matching of component ends. The threaded nature of the joining system is pre-loaded-able, secure, and economical with the use of off-the-shelf hardware. This joint system also accommodates external c-clamp type hardware designed for fast assembly.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement which is calculated to achieve the same purpose may be substituted for the specific embodiment shown. This application is intended to cover adaptations or variations of the present subject matter. It is to be understood that the above description is intended to be illustrative, and not restrictive. Combinations of the above embodiments as well as combinations of portions of the above embodiments in other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the present subject matter should be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.